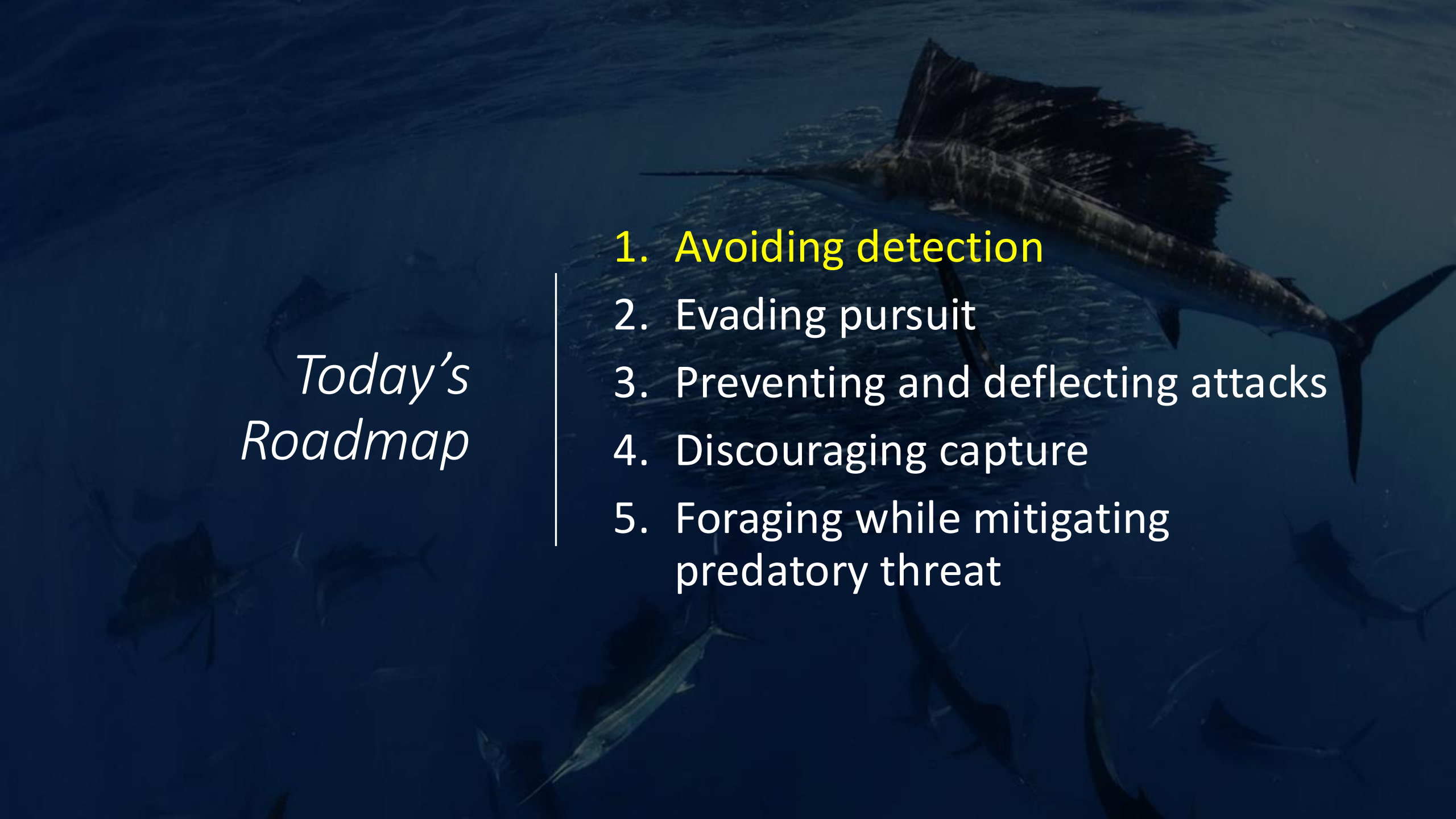
Predators & Prey II: **Fishes as Prey**

FISH 310

Photo by Paul Nicklen



Today's Roadmap

1. Avoiding detection
2. Evading pursuit
3. Preventing and deflecting attacks
4. Discouraging capture
5. Foraging while mitigating predatory threat

Either **avoid detection** or **detect the predator first**

- The earliest intervention in predation = **camouflage,** but *how can you stay camouflaged while still searching for food*?
- Decrease photocontrast with the environment (= **protective resemblance**)

Ghost Pipefish (Syngnathidae)

Pygmy Seahorse(Syngnathidae)

Either **avoid detection** or **detect the predator first**

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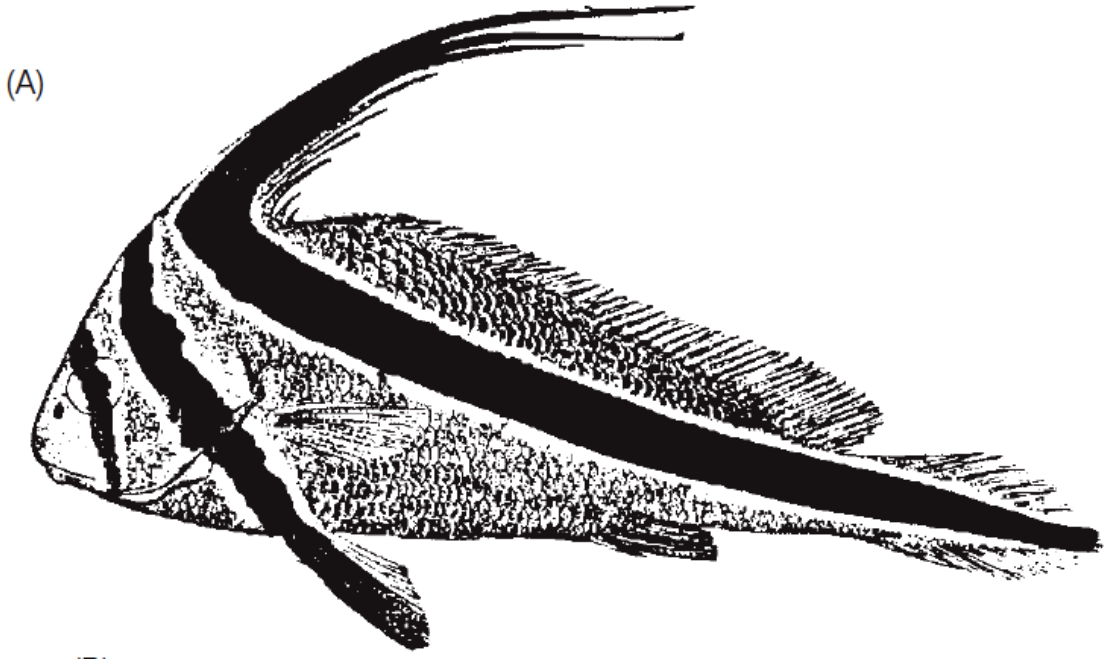
Juvenile Batfish (Ephippidae)

Juvenile Sweetlip (Haemulidae)

Either **avoid detection** or **detect the predator first**

- The earliest intervention in predation = **camouflage,** but *how can you stay camouflaged while still searching for food*?
- Decrease photocontrast with the environment (= **protective resemblance**)
- **Disrupt outline** of the fish's body



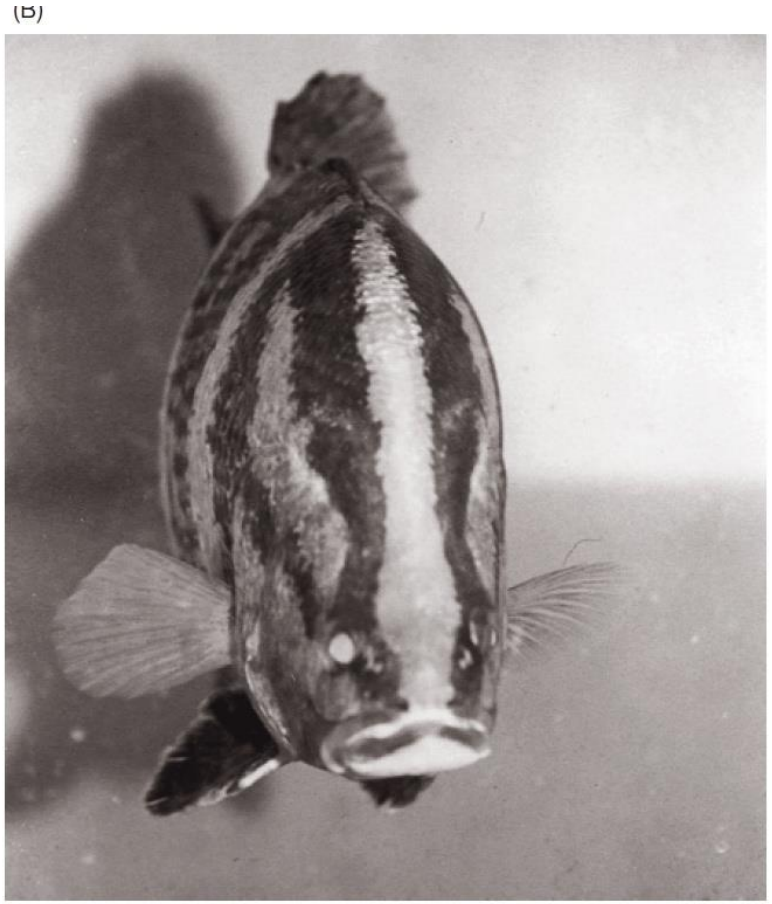
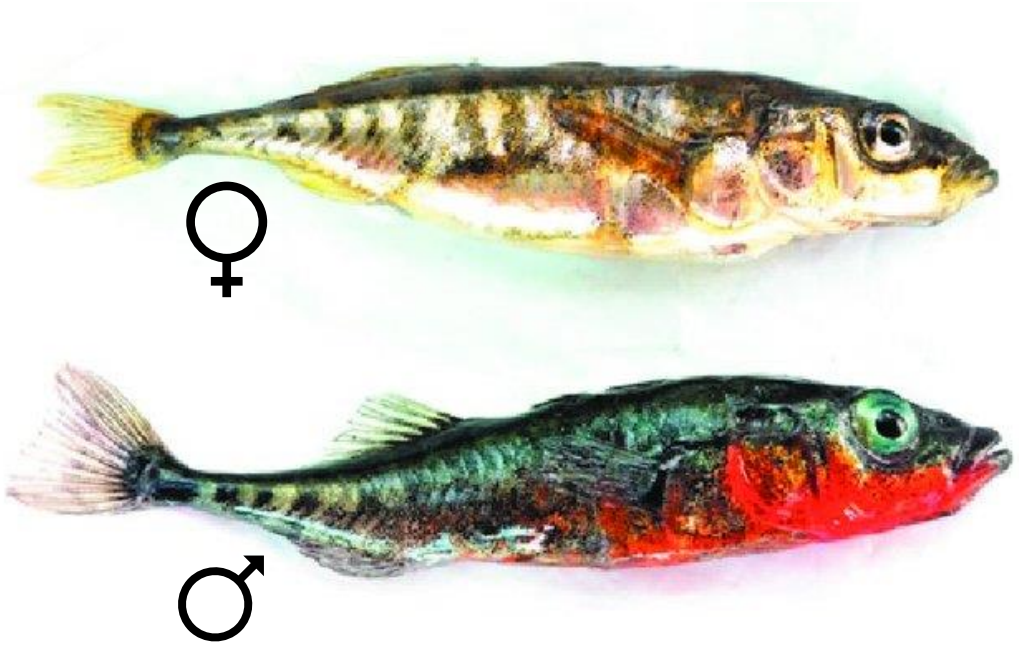


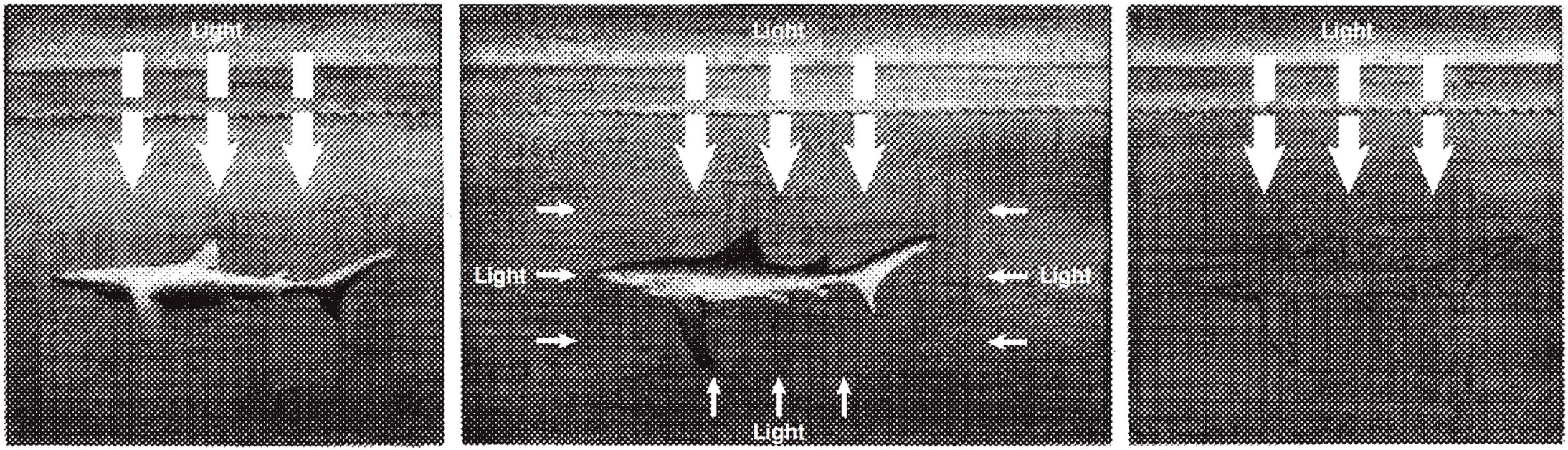
Figure 20.2
Examples and functions of disruptive coloration in fishes. (A) The Jacknife Fish, *Eques lanceolatus*, may use boldly contrasting, dark and light regions to emphasize those parts of its outline that are not fishlike in appearance, thus momentarily confusing a potential predator. (B) Many lurking predators possess a dark or light interorbital stripe that could disrupt their head outline when viewed head-on, making recognition by prey momentarily difficult. This large (*c*. 45 cm) Japanese Snook (probably *Lates japonicus*) has a distinctive, light colored interorbital stripe. (A) from Cott (1957), used with permission; (B) photo by J. DeVivo.

Either **avoid detection** or **detect the predator first**

- The earliest intervention in predation = **camouflage,** but *how can you stay camouflaged while still searching for food*?
- Decrease photocontrast with the environment (= **protective resemblance**)
- Disrupt outline of the fish's body
- Become invisible: **countershading**, **silvery sides**, or **transparency**



Reverse countershading
in the male stickleback
Rastorguev et al. 2018



(A) (B) (C)

Figure 20.3

Countershaded fishes disappear in the water column because their graded coloration reflects light in a manner that makes them match natural background light. (A) A *uniformly colored* gray fish illuminated primarily from above (= *natural lighting*) would have a relatively bright dorsum and a relatively dark ventrum. (B) A *countershaded* fish viewed under unnaturally uniform illumination, as in flash photography, is not camouflaged because it contrasts with the gradient of illumination of background light. (C) In a *countershaded* fish viewed under *natural lighting* conditions, the gradual transition from dark dorsum to light ventrum, which is opposite to the actual distribution of background light, has an averaging or canceling effect. In this way the top of the fish is seen as dark against dark, the middle as intermediate brightness against intermediate, and the light belly as light against light. All color-background combinations eliminate the contrast between the fish and its background.

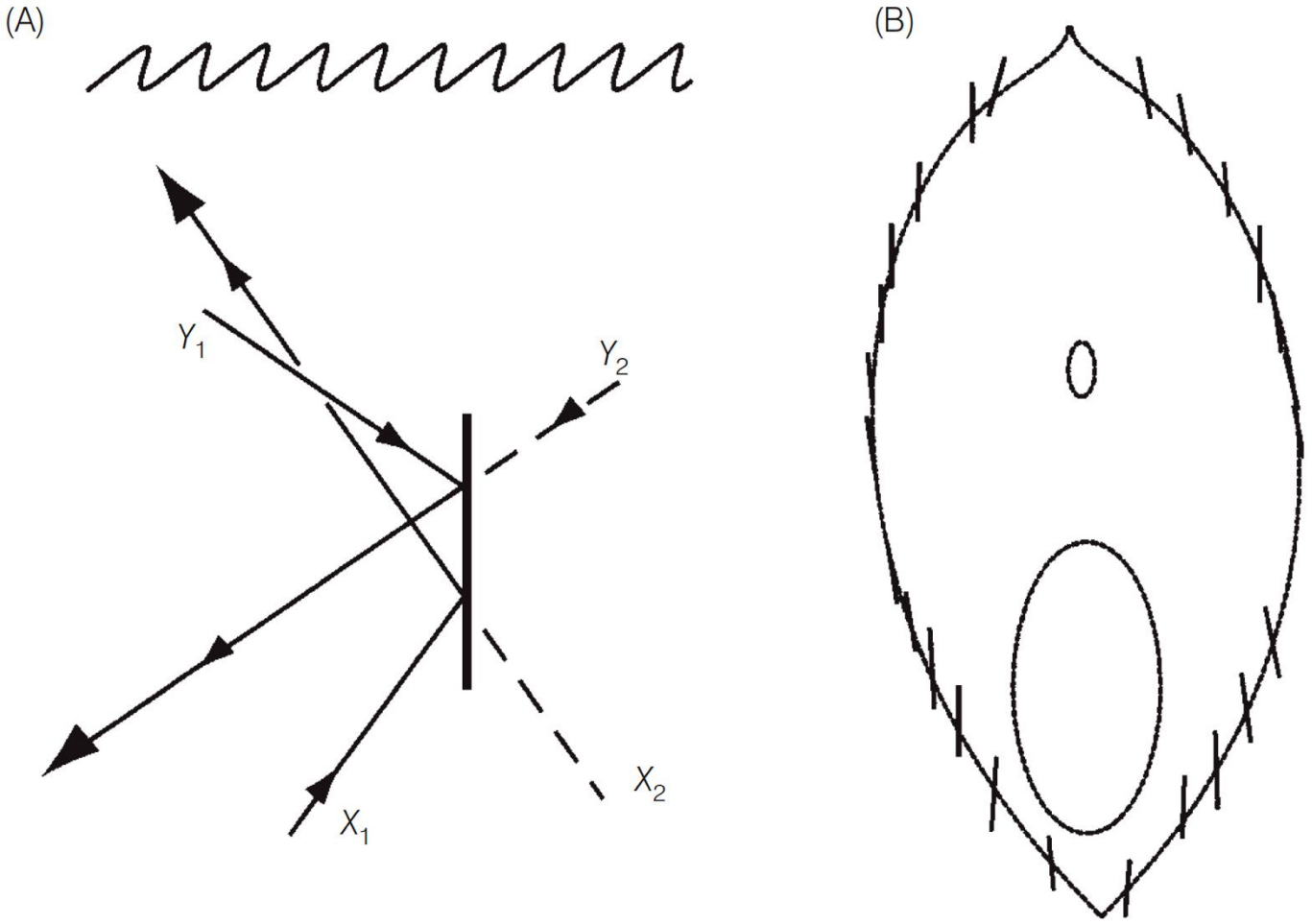


Figure 20.5

The functional morphology of mirror sides in fishes. (A) A clear plate of glass suspended in water is invisible because background light passes directly through it (extensions of dashed lines X_2 and Y_2 to the observer's eyes); an observer sees no difference between the glass plate and its background. A mirror suspended in water also disappears because light reflected off the mirror (solid lines X_1 and Y_1) is identical to the background light that would pass through the object if it were clear (dashed lines). (B) Cross-section through the body of a Bleak (*Alburnus alburnus*) to show orientation of the reflective platelets in silvery fishes. The platelets are embedded in the skin and scales and are oriented vertically, even along the curved surfaces of the fish. After Denton and Nicol (1965).

Schilbeidae (Glass Catfish)

Parambassis (Glass Fish)

Pristella (X-ray Tetra)

Prionobrama (Glass Bloodtail)

Detecting the predator first

- **Relative visual advantage:** a shaded fish has an advantage over a sunlit fish
- Turbidity results in a **veil of brightness**
- Resting fishes often hover in the shade
- Nocturnal fishes form "daytime resting schools"
- Predators take advantage of the shade, too!

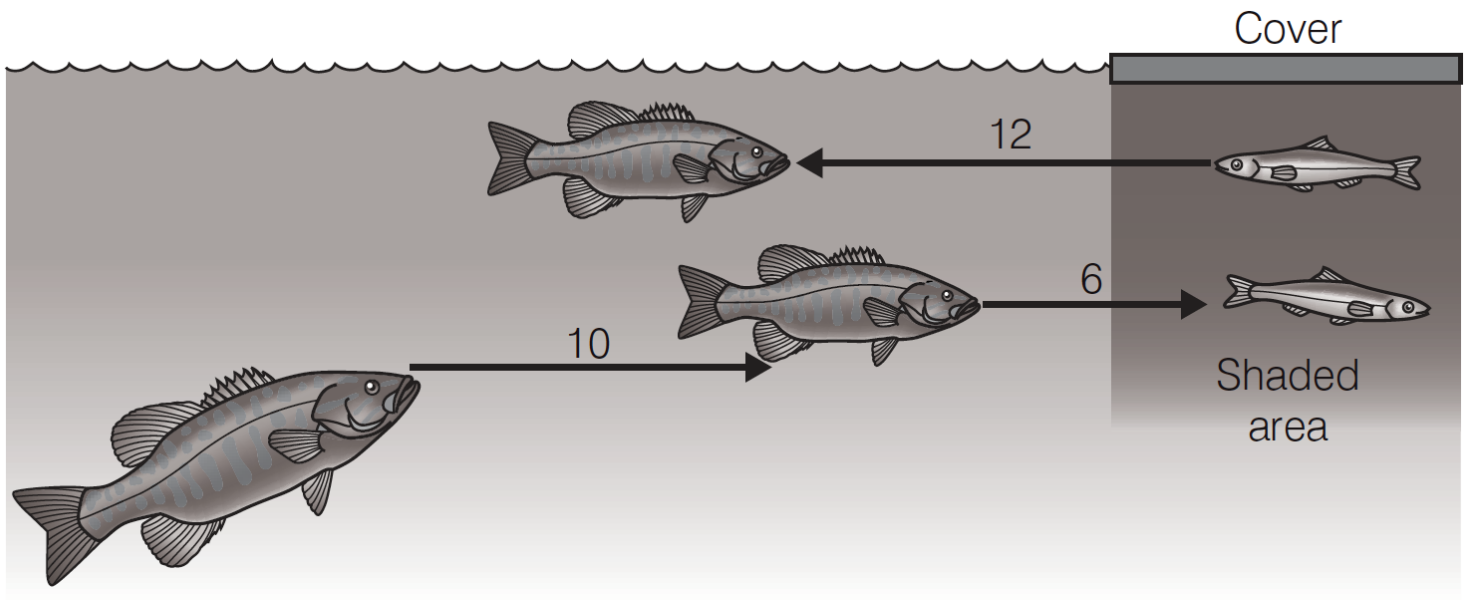
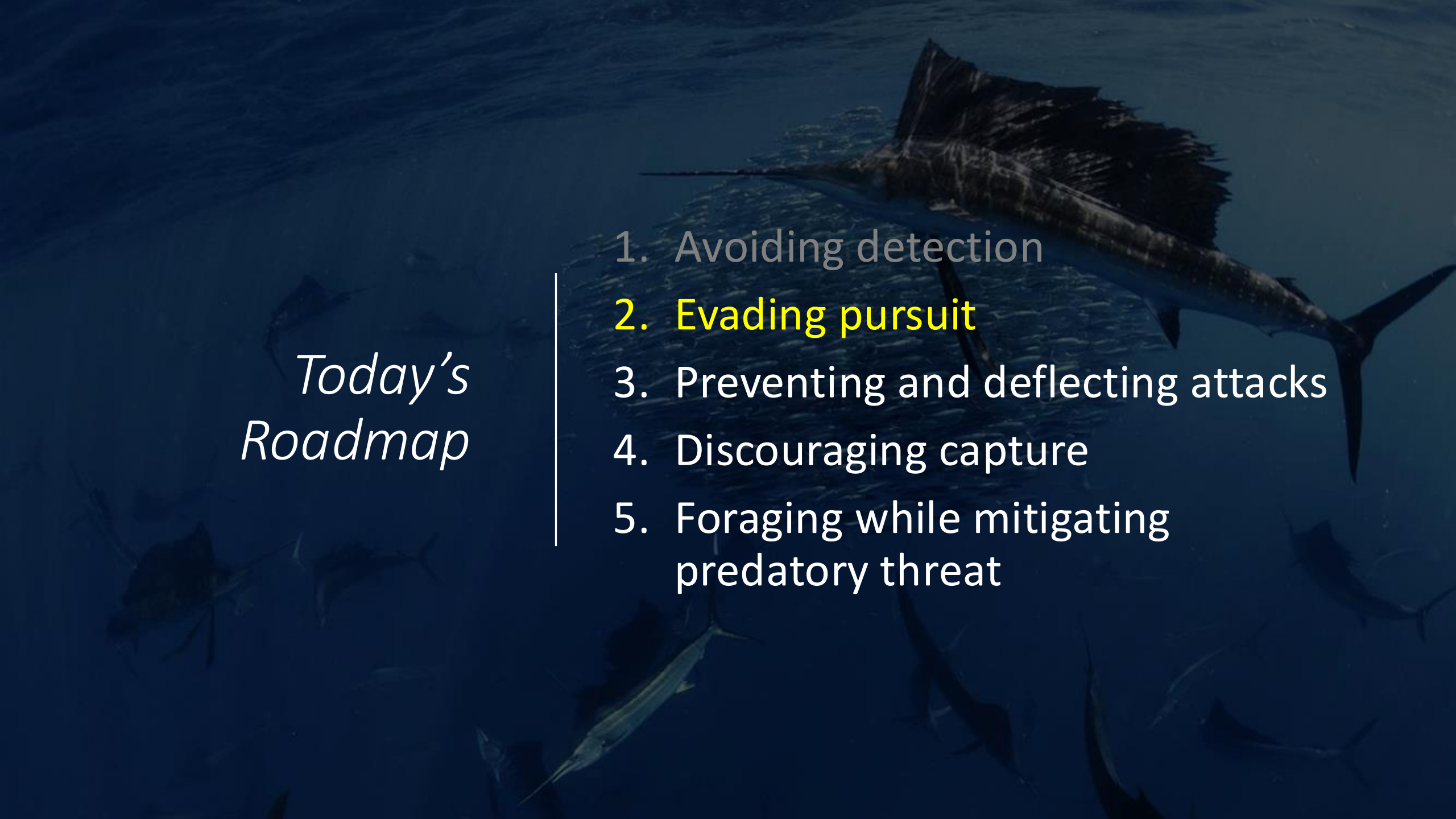


Figure 20.6

The advantage to fishes of hovering in shade. On a sunny day in a lake, a shaded observer has a relative visual advantage over sunlit observers. When horizontal visibility is 10 m, a shaded observer can detect sunlit objects 12 m away, which is approximately 1.2 times better visibility than experienced by a sunlit observer viewing a sunlit target (= a 20% advantage over ambient conditions). More significantly, the sunlit observer cannot see an object in the shade until it is 6 m away, which gives the shaded observer a 100% advantage over the sunlit observer. The relative visual advantage decreases on cloudy days, as does the attractiveness of overhead objects. After Helfman (1979b, 1981a).

Advantages of shoaling

- **Group formation as an alternative to advanced protective resemblance**
- **Polarized schooling tactics**:
  - Synchronized movements
  - Streaming behavior
  - **Predator inspection visits**
  - **Mobbing**



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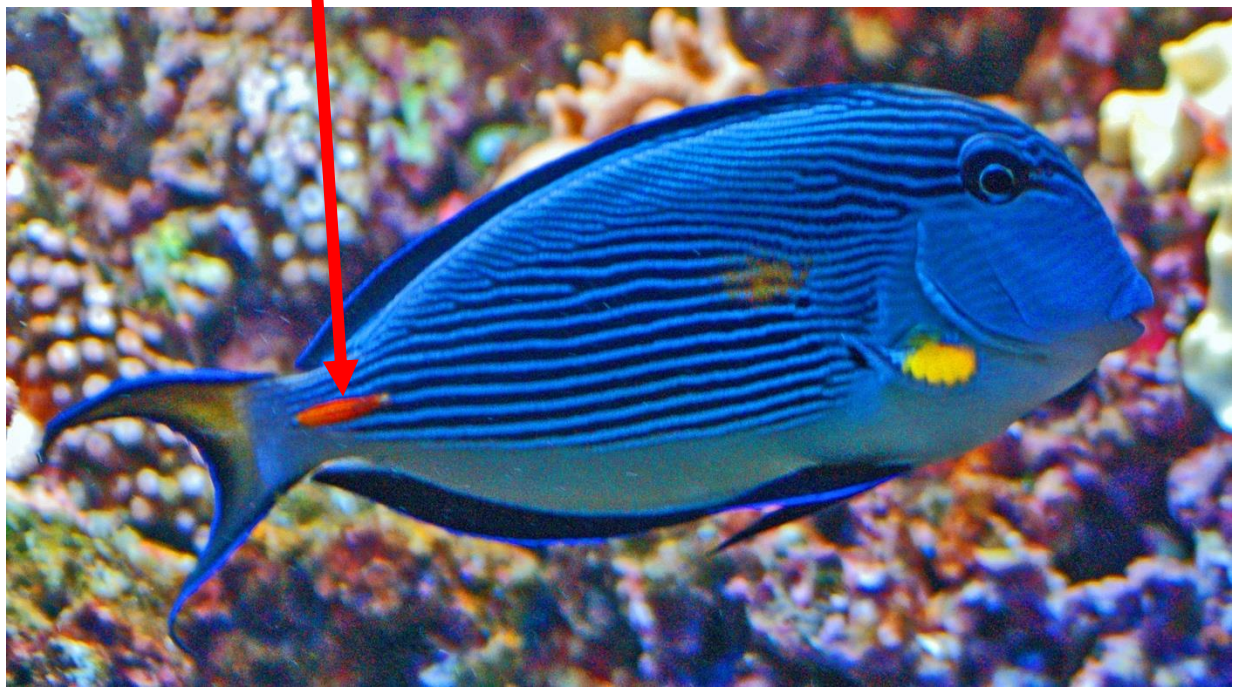
Evading pursuit

- Aposematic coloration & chemical or physical deterrents

sharp scalpel-like enlarged scale!



Evading pursuit

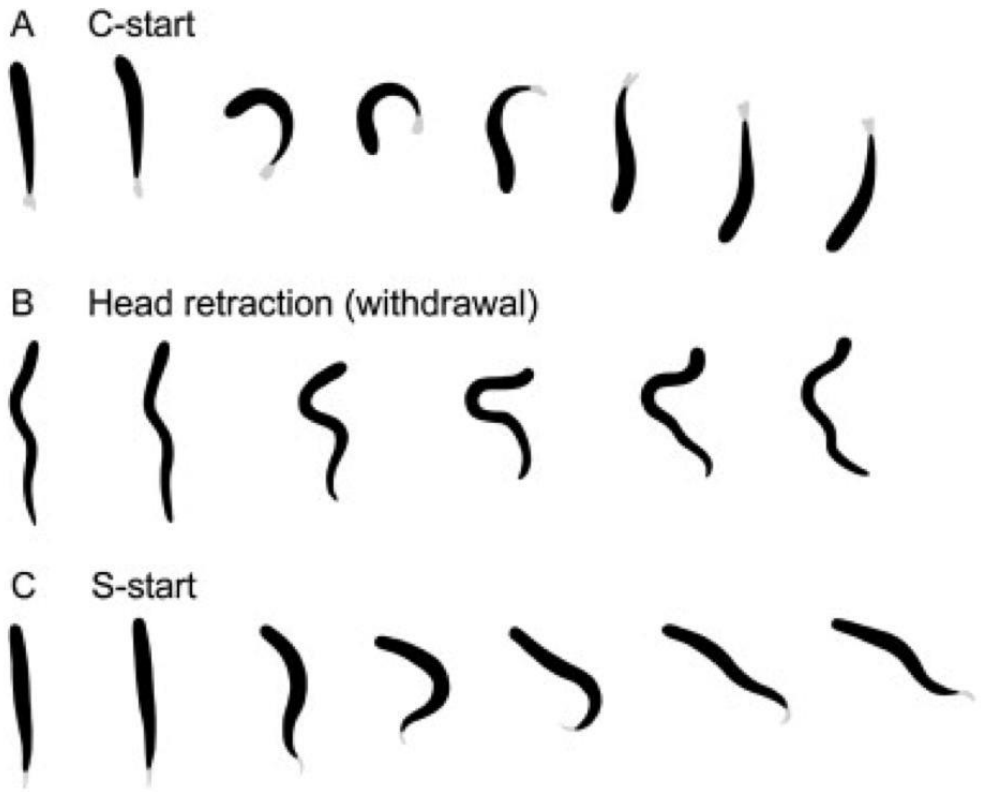
- Aposematic coloration & chemical or physical deterrents
- Hiding in bottom structure or vegetation

Garden Eels (Congridae)

pearly razorfish (*Xyrichtys novacula*)

Evading pursuit

- Aposematic coloration & chemical or physical deterrents
- Hiding in bottom structure or vegetation
- Outmaneuvering the predator

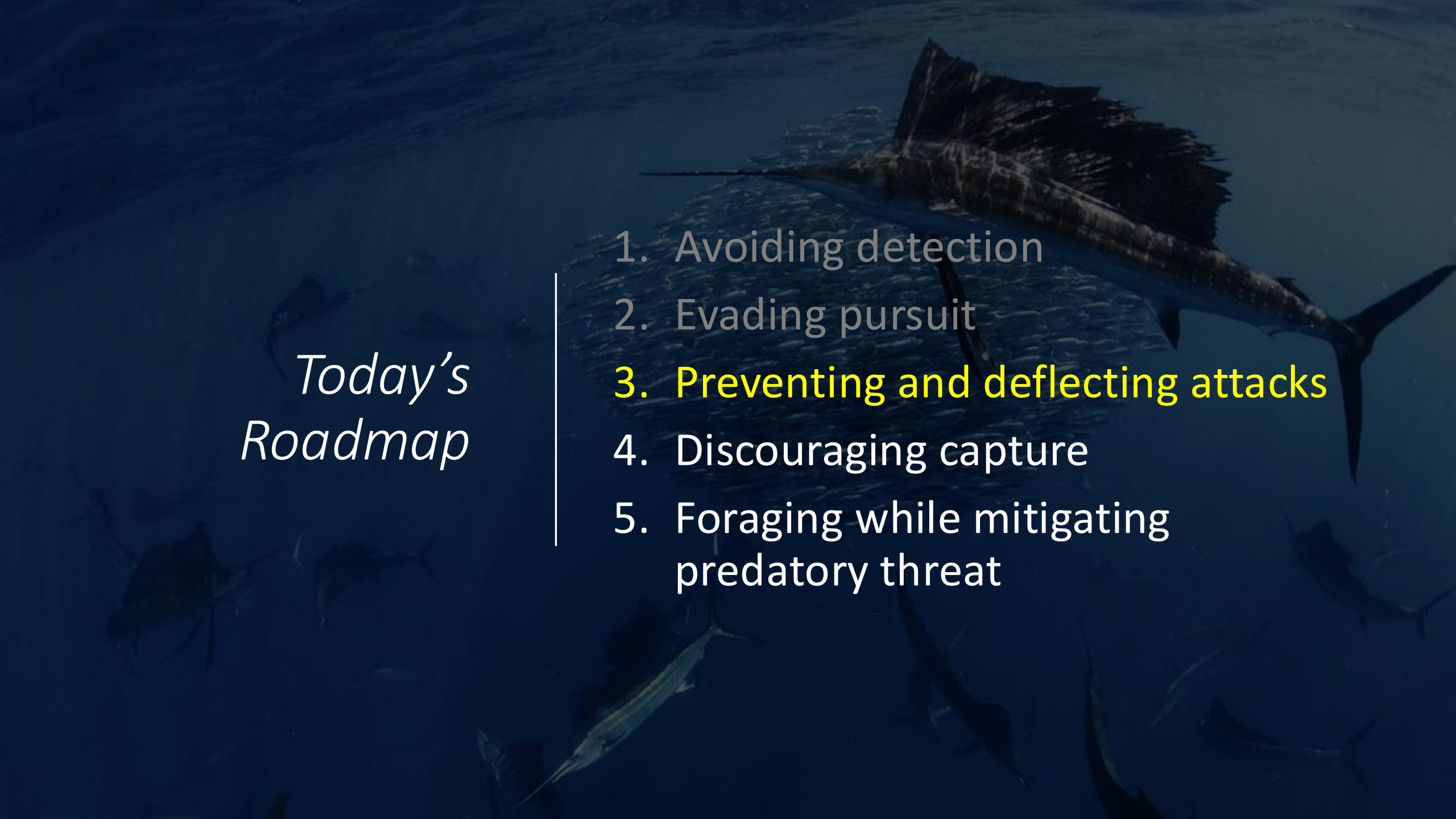


Silhouettes of fish startle responses from Liu and Hale (2014) *Zoology*, Fig 1

Evading pursuit

- Aposematic coloration & chemical or physical deterrents
- Hiding in bottom structure or vegetation
- Outmaneuvering the predator
- Becoming airborne

Flying Fish
(Exocoetidae)



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Escape maneuvers to prevent or deflect attacks

- Fast start escape movements (individual)
- Group behaviors
  - Aggregation means each individual is less likely to be attacked = Attack abatement or dilution effect
  - Trafalgar effect = info. about predator communicated to individuals that haven't yet encountered the predator
  - Confusion effect = predators switch targets repeatedly
    - Skittering
    - Protean behavior
    - Roll & flash

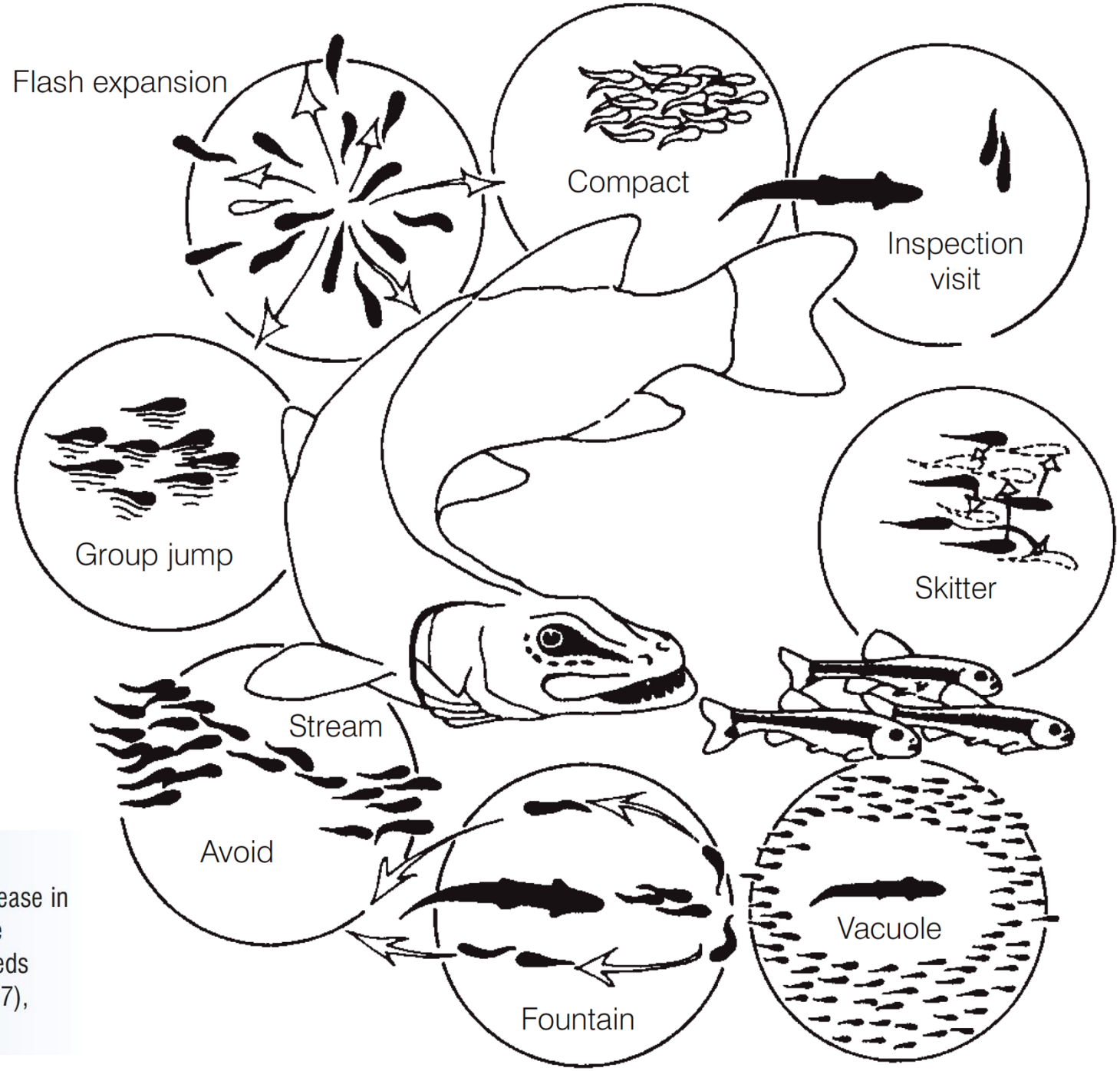
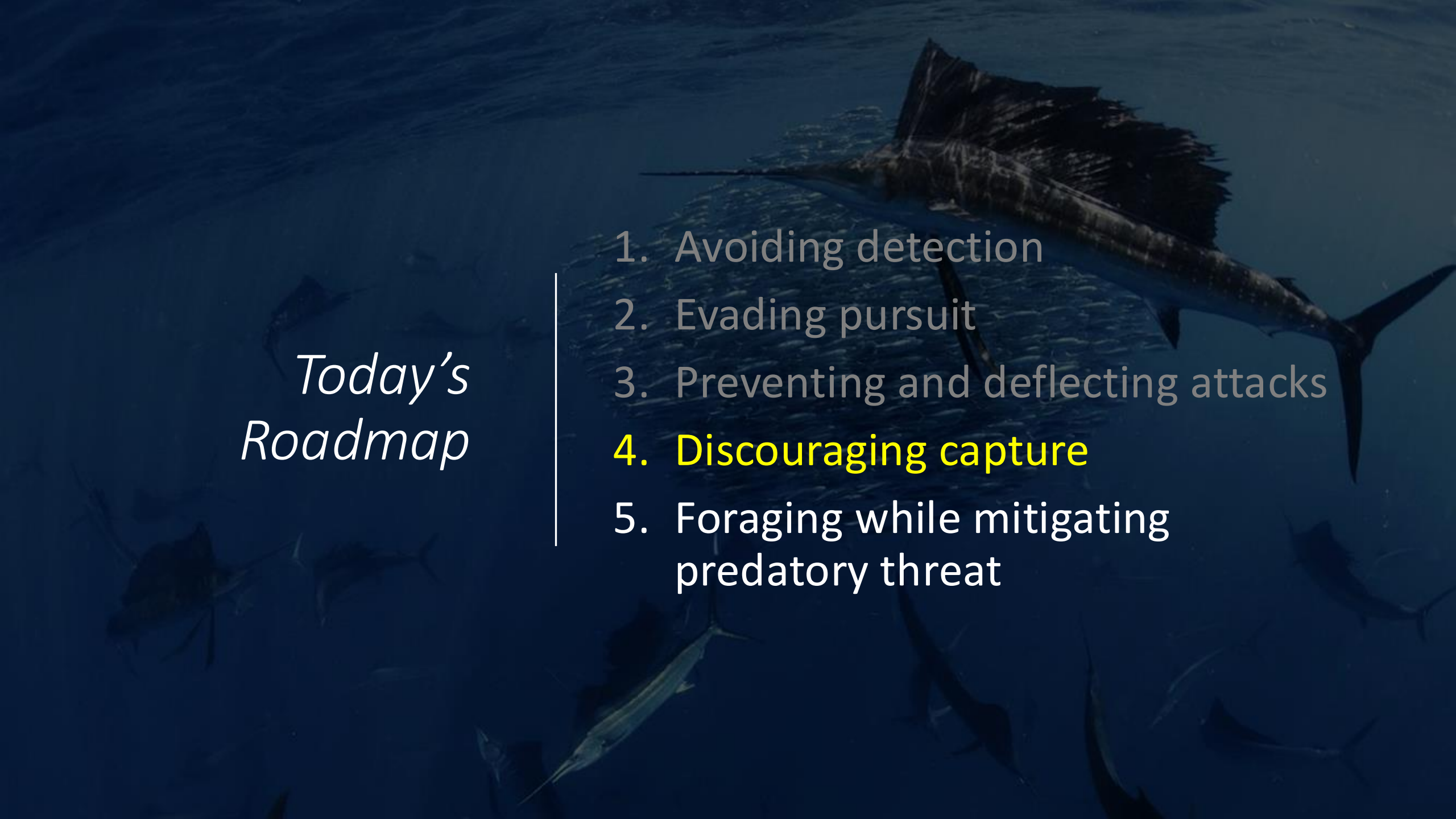


Figure 20.8

The graded responses of minnows under attack. Responses increase in intensity as the predator's actions become more threatening. The hierarchy of responses begins at the top ("compact") and proceeds clockwise to "flash expansion". From Magurran and Pitcher (1987), used with permission.



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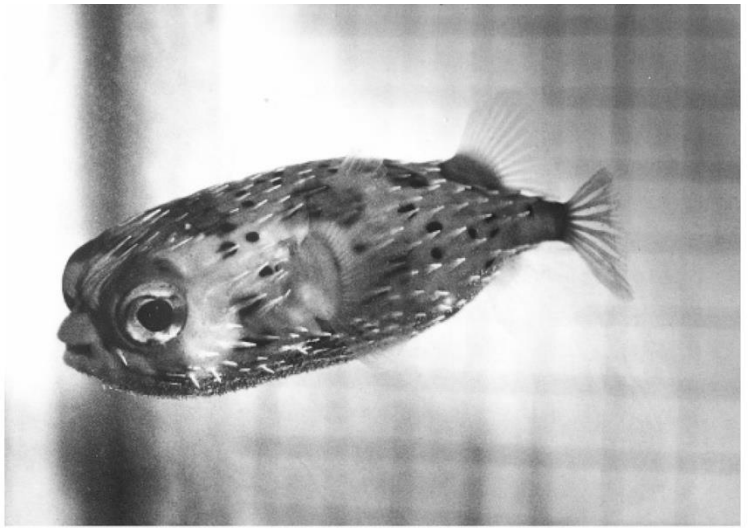
How to prevent ingestion

- **Exploit gape limitation: make it hard to close the mouth around prey**
  - Increased body depth
  - Elongate fins
  - Inflating stomachs, erecting spines



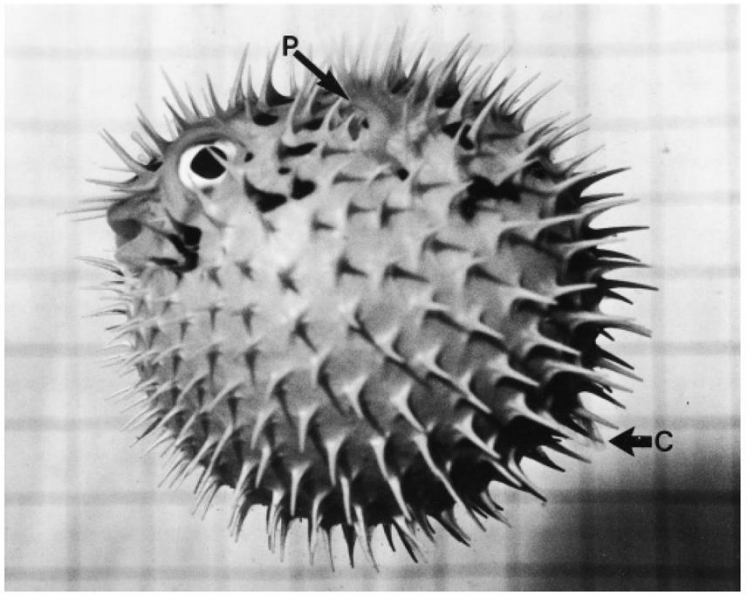


Figure 20.9

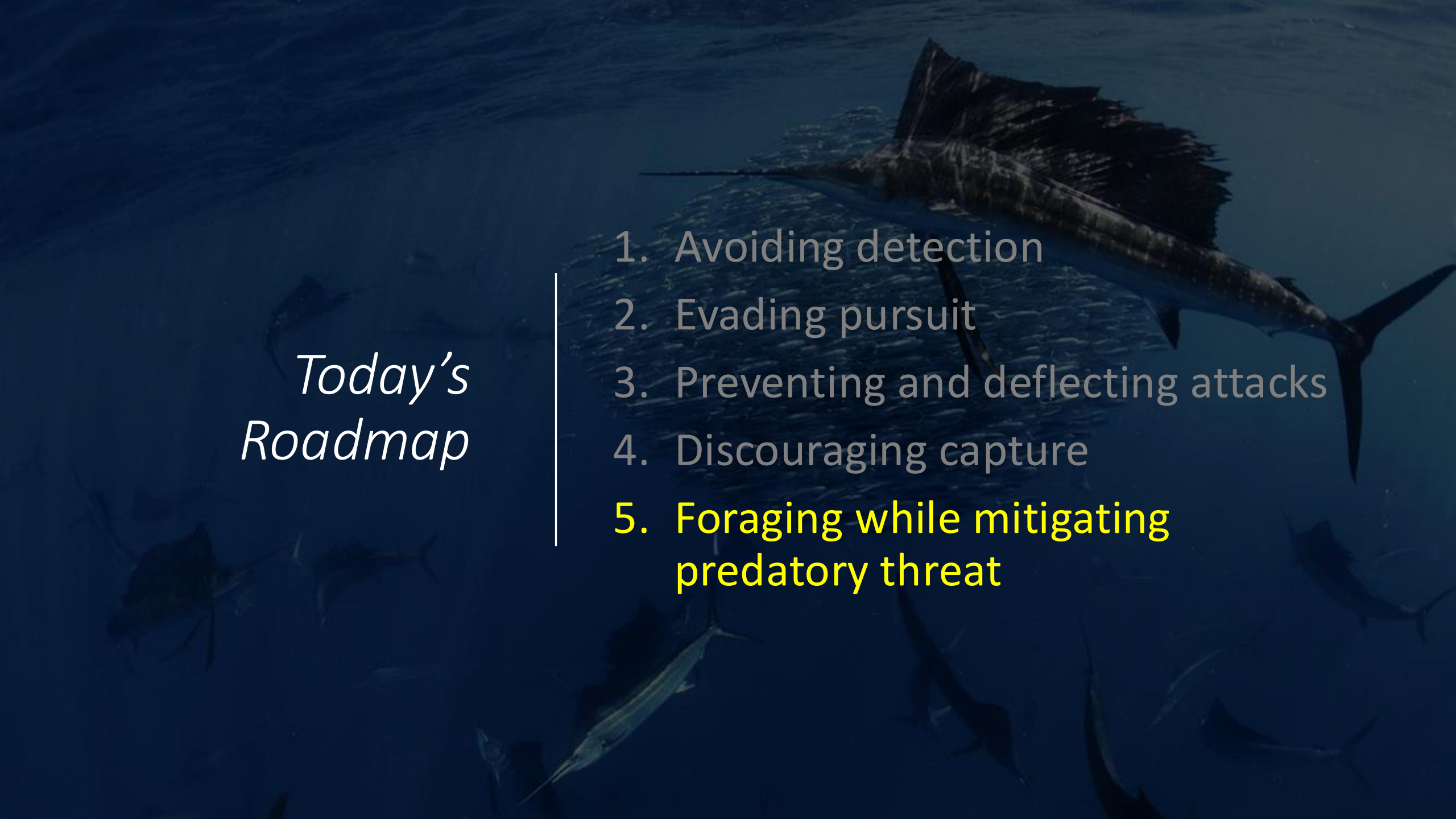
Balloonfish inflate themselves with water in response to being handled by potential predators. They undergo a three-fold increase in volume, which turns them into a sphere with projecting spines. Extremities that might offer a predator a grasping point, such as the caudal (C), pectoral (P), and other fins, sit largely within the protective framework of the spines when the fish is inflated. Inflation occurs as water is pumped into the stomach, which expands up to 100-fold to fill an unusually large peritoneal space. The spines are embedded in a highly derived, stretchable skin. From Brainerd (1992), used with permission.

Perca fluviatalis
Eurasian Perch

How to prevent ingestion

- Exploit gape limitation: make it hard to close the mouth around prey
  - Increased body depth
  - Elongate fins
  - Inflating stomachs, erecting spines
- **Make handling complicated**
  - Slime
  - Distasteful skin toxins
  - Thickened dermis
  - Deciduous scales
  - Schreckstoff substance

Convict Cichlid
Archocentrus nigrofasciatus



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Foraging-predation risk **trade-off**

- Foraging behavior changes in the presence of predators, resulting in different
  - Foraging locations
  - Foraging rates & quantities
  - Growth rates
- Fishes weigh the risks → **threat sensitivity**

Juvenile & adult bluegill *Lepomis macrochirus*